




## Control of *Conyza* spp. with sequential application of glufosinate in soybean pre-sowing

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**ABSTRACT:** *Conyza* spp. is among the main weeds reported worldwide. Due to its aggressiveness, such as high seed production and dispersion, and the growing reports of biotypes resistant to glyphosate, paraquat, and other herbicides, different control practices are required. Thus, this study aimed to evaluate the efficacy of herbicides with sequential application of glufosinate in soybean pre-sowing for control of *Conyza* spp. with indicative of resistant to paraquat. The study was carried out in the field, at Assis Chateaubriand and Palotina, state of Paraná, Brazil, in the 2018/19 season. The experiments were conducted in a randomized block design with four replications. The treatments consisted in application of glyphosate, 2,4-D, saflufenacil, glufosinate, saflufenacil/imazethapyr, diclosulam, paraquat/diuron, paraquat and imazethapyr/flumioxazin, at different combinations, in soybean pre-sowing. Control of *Conyza* spp., crop injury to soybean plants and variables related to agronomic performance (plant height and yield) were evaluated. All treatments were selective for soybean, which showed stronger crop injury in the presence of diclosulam herbicide, but this did not compromise soybean agronomic performance. In general, control levels were high for the treatments used. Except for paraquat treatments, in the area with the highest frequency of *Conyza* spp. with indicative of resistant to paraquat, and imazethapyr/flumioxazin treatment in both areas. These control results emphasized the importance of glufosinate in this management system and showed promising results for saflufenacil/imazethapyr.

**Key words:** glyphosate resistance, paraquat resistance, glutamine synthetase inhibitors, *Glycine max* L. Merr.

## Controle de *Conyza* spp. com aplicação sequencial de glufosinate em pré-plantio da soja

**RESUMO:** A planta daninha *Conyza* spp. está entre as principais encontradas em todo o mundo. Devido a sua agressividade, como elevada produção e dispersão de sementes e os crescentes relatos de biótipos resistentes ao glyphosate, paraquat e outros herbicidas, faz-se necessário o uso de diferentes ferramentas de manejo. Assim, o objetivo deste estudo foi avaliar a eficácia de herbicidas com aplicação sequencial de glufosinate em pré-plantio da soja, no controle de *Conyza* spp. com indicativo de resistência ao paraquat. O estudo foi realizado em campo nos municípios de Assis Chateaubriand e Palotina, estado do Paraná (PR), Brasil, na safra 2018/19. O delineamento experimental utilizado foi o de blocos casualizados, com quatro repetições. Os tratamentos foram compostos pela aplicação de glyphosate, 2,4-D, saflufenacil, glufosinate, saflufenacil/imazethapyr, diclosulam, paraquat/diuron, paraquat e imazethapyr/flumioxazin, em diferentes combinações em pré-plantio da soja. Foram avaliados controle de *Conyza* spp., sintomas de injúria nas plantas de soja e variáveis relacionadas ao desempenho agrônomo (altura de plantas e produtividade). Todos os tratamentos mostraram-se seletivos a soja. Visualizou-se maiores sintomas de injúria quando se tinha a presença do herbicida diclosulam, mas não resultou em danos ao desempenho agrônomo da soja. De forma geral os níveis de controle foram altos para os tratamentos utilizados, em exceção para os tratamentos com paraquat na área que apresentava maior frequência de *Conyza* spp. com indicativo de resistência a este herbicida, e para o tratamento com imazethapyr/flumioxazin nas duas áreas. Estes resultados de controle enfatizam a importância do glufosinate neste sistema de manejo e demonstram resultados promissores para saflufenacil/imazethapyr.

**Palavras-chave:** resistência a glyphosate, resistência a paraquat, inibidores da glutamina-sintetase, *Glycine max* L. Merr.

## INTRODUCTION

Hairy fleabane (*Conyza bonariensis*), horseweed (*Conyza canadensis*) and Sumatran fleabane (*Conyza sumatrensis*) is among the main

weeds found worldwide (TRAINER et al. 2005). *Conyza* spp. is an annual herbaceous plant, belonging to Asteraceae family, (LORENZI, 2014) with high seed production, reported in various agricultural environments, such as grain crops and in undisturbed

areas (MOREIRA & BRAGANÇA, 2011). The dispersion of *Conyza* spp. occurs exclusively by seeds present in the achene fruit. The number of seeds varies from 100 to 200 thousand per plant (DAUER et al., 2007).

In addition to the high seed production and dispersion, these three species have 105 reported herbicide-resistant biotypes (HEAP, 2020). For example, *C. sumatrensis* shows multiple resistance to glyphosate and chlorimuron (SANTOS et al., 2014). Recent studies showed there are biotypes of *C. sumatrensis* with resistance to paraquat (state of Paraná) (ZOBIOLE et al., 2019), or 2,4-D (state of Rio Grande do Sul) (QUEIROZ et al., 2020).

The use of herbicide combinations, rotation of sites of action, rotation of transgenic events, cover crops, crop rotations, and others are key in the management, and prevention of selection of herbicide resistant weed biotypes (BROSTER et al., 2019; MacLAREN et al., 2019; ROSARIO-LEBRON et al., 2019). In addition, the use of pre-emergence and burndown herbicides at tank-mixed before sowing soybeans for effective management of *C. sumatrensis* resistant to paraquat. Among the burndown herbicides can be highlighted the glufosinate (MONTGOMERY et al., 2017; ZOBIOLE et al., 2018). While, other

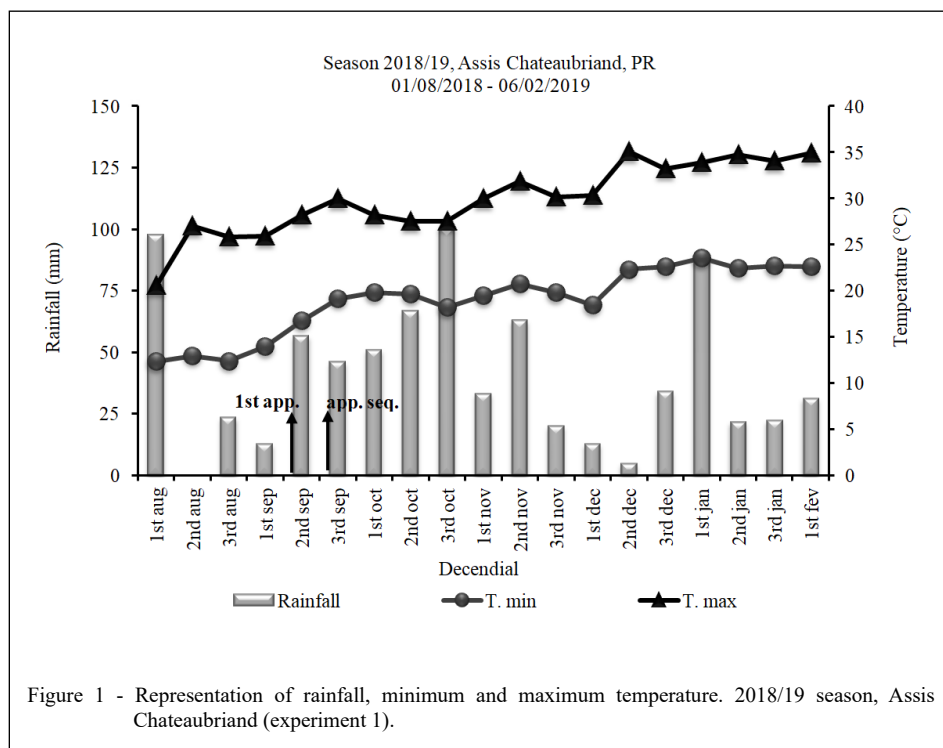
studies highlighted the efficacy of herbicides with pre-emergent action in controlling *Conyza* spp. in soybeans. These herbicides include flumioxazin (ZIMMER et al., 2018), diclosulam (BRAZ et al., 2017), imazethapyr (HEDGES et al., 2019), among others.

Thus, in order to control *C. sumatrensis*, with recent cases of resistance to paraquat and 2,4-D, the use of alternative herbicides should be considered. Therefore, the aim of this study was to evaluate the efficacy of herbicides, with sequential application of glufosinate in soybean pre-sowing, at control of *Conyza* spp. with indicative of resistance to paraquat.

## MATERIALS AND METHODS

### Site description and experimental design

The experiments were carried out in the field, in the 2018/19 season, at Assis Chateaubriand - experiment 1 - (24°34'774"S 53°86'1'856"W) and Palotina - experiment 2 - (24°20'44.54"S 53°51'50.93"W), state of Paraná (PR), Brazil. The predominant climate in this region is Cfa, a subtropical climate with warm summer, according to the Köppen classification (PEDRON et al., 2013) the weather conditions for the experimental period are illustrated in figures 1 and 2. For experiment



1, the soil was classified as clay texture (66.25% clay, 18.75% silt and 15% sand) with the following chemical characteristics in the 0-20 cm layer: pH (CaCl<sub>2</sub>) of 4.8, 1.55% OM and CEC of 12.41 cmol<sub>c</sub> dm<sup>-3</sup>. For experiment 2, the soil was also classified as clay texture (66.25% clay, 16.25% silt and 17.5% sand), with pH (CaCl<sub>2</sub>) of 5.2, 3.7% OM and CEC of 14.64 cmol<sub>c</sub> dm<sup>-3</sup>.

Previously, the areas were cultivated with maize, and the experiments were infested with *Conyza* spp. with indicative of resistance to paraquat. For experiment 1 with a density of 13 plants m<sup>-2</sup> (> 15 cm) and 3 plants m<sup>-2</sup> (<15 cm), with about 35% population of plants with indicative of resistance to paraquat. For experiment 2, the infestation was 11 plants m<sup>-2</sup> (> 15 cm) and 8 plants m<sup>-2</sup> (<15 cm), with about 5% population plants with indicative of resistance to paraquat. To determine the frequency of the plants with indicative of resistance to paraquat, 14 days before the experiment was installed, paraquat (Gramoxone® 200) application at tracks was performed, at label rate (400 g a.i. ha<sup>-1</sup>). The number of uncontrolled plants (≤20% of control), with 6 to 10 leaves (4 to 8 cm height), was evaluated, compared to the track without application, before and after application. Seven days after the paraquat

application, a second application was performed to determine the frequencies.

Soybean sowing occurred in no-tillage system, with 0.45 cm spacing between rows and 4 to 5 cm of sowing depth. The soybean cultivar BS 2606 IPRO (BASF S.A., São Paulo, SP, Brazil) was used for experiment 1 and Monsoy® 5947 IPRO (Monsanto Co. Brazil, São Paulo, SP, Brazil) for experiment 2. The experiments were a randomized block design with four replications. The plots were composed of six soybean rows with 5 meters of length. Treatments for the control of *Conyza* spp. are described in table 1. The dates of application, sowing and environmental conditions during applications are listed in table 2. Sequential application occurred on the same day for experiment 1, while in experiment 2 one day before sowing.

All applications were performed with a pressurized CO<sub>2</sub> backpack sprayer equipped with six AIXR 110.015 nozzles at a pressure of 2.5 kgf.cm<sup>-2</sup> and a speed of 3.6 km h<sup>-1</sup>, providing an application volume of 150 L ha<sup>-1</sup>.

#### Evaluations

The control of *Conyza* spp. was evaluated at soybean sowing and at 1, 3 and 5 weeks after

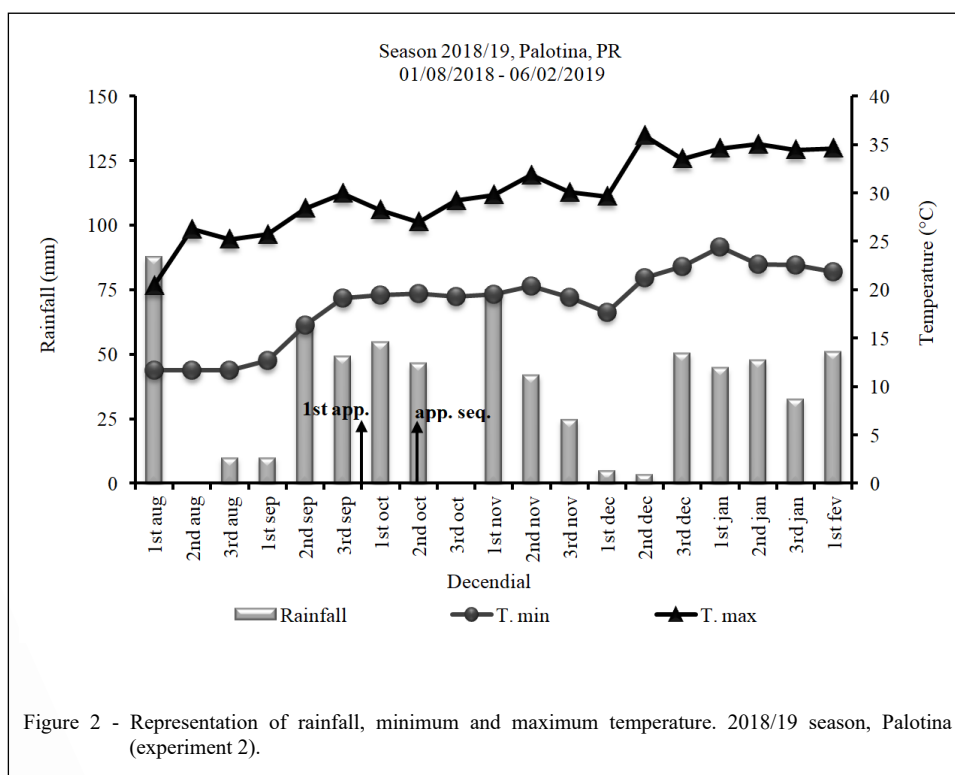


Table 1 - Treatments for the control of *Conyza* spp. 2018/19 season.

Treatments <sup>a</sup>	Rates <sup>b</sup>
weedy control (without application)	-
glyphosate + 2,4-D <i>seq.</i> glufosinate <sup>1</sup>	1500 + 670 <i>seq.</i> 400
glyphosate + 2,4-D + saflufenacil <sup>1</sup> <i>seq.</i> glufosinate <sup>1</sup>	1500 + 670 + 35 <i>seq.</i> 400
glyphosate + saflufenacil <sup>1</sup> <i>seq.</i> glufosinate <sup>1</sup>	1500 + 35 <i>seq.</i> 400
glufosinate + saflufenacil/imazethapyr <sup>1</sup> <i>seq.</i> glufosinate <sup>1</sup>	600 + 35.6/100.4 <i>seq.</i> 400
glufosinate + 2,4-D <sup>1</sup> <i>seq.</i> glufosinate <sup>1</sup>	600 + 670 <i>seq.</i> 400
paraquat/diuron <sup>2</sup> <i>seq.</i> glufosinate <sup>1</sup>	400/200 <i>seq.</i> 400
glufosinate + saflufenacil/imazethapyr <sup>1</sup> <i>seq.</i> glufosinate <sup>1</sup>	400 + 35.6/100.4 <i>seq.</i> 400
glyphosate + glufosinate <sup>1</sup> <i>seq.</i> glufosinate <sup>1</sup>	1500 + 400 <i>seq.</i> 400
glyphosate + diclosulam <i>seq.</i> glufosinate <sup>1</sup>	1500 + 25.2 <i>gseq.</i> 400
glyphosate + diclosulam + saflufenacil <sup>1</sup> <i>seq.</i> glufosinate <sup>1</sup>	1500 + 25.2 <i>g seq.</i> 400
glufosinate + saflufenacil/imazethapyr + 2,4-D <sup>1</sup> <i>seq.</i> glufosinate <sup>1</sup>	600 + 35.6/100.4 + 670 <i>seq.</i> 400
paraquat <sup>2</sup> <i>seq.</i> glufosinate <sup>1</sup>	400 <i>seq.</i> 400
2,4-D + saflufenacil/imazethapyr <sup>1</sup> <i>seq.</i> glufosinate <sup>1</sup>	670 + 35.6/100.4 <i>seq.</i> 400
glyphosate + imazethapyr/flumioxazin <sup>1</sup> <i>seq.</i> glufosinate <sup>1</sup>	1500 + 100/50 <i>seq.</i> 400
weed-free control (without application)	-

<sup>a</sup>Commercial products: Zapp<sup>®</sup> QI 620 (glyphosate), DMA<sup>®</sup> 806 BR (2,4-D), Heat<sup>®</sup> (saflufenacil), Finale<sup>®</sup> (glufosinate), Optill<sup>®</sup> (saflufenacil/imazethapyr), Spider<sup>®</sup> 840 WG (diclosulam), Gramocil<sup>®</sup> (paraquat/diuron), Gramoxone<sup>®</sup> 200 (paraquat), Zethamaxx<sup>®</sup> (imazethapyr/flumioxazin).

<sup>b</sup>Rates at g a.e. ha<sup>-1</sup>, for glyphosate, 2,4-D and imazethapyr. Rates at g a.i. ha<sup>-1</sup>, for other herbicides. <sup>1</sup>Adjuvant Mees<sup>®</sup> (500 mL ha<sup>-1</sup>) use.

<sup>2</sup>Adjuvant Agral<sup>®</sup> (250 mL ha<sup>-1</sup>) use. *seq.*: sequential application.

sequential herbicide application (WAA). After the last control evaluation, all the plots of the treatments were weeded except the weedy control. At 2 and 5 weeks after sowing (WAS), crop injury in the soybean plants was evaluated. These evaluations were carried out through visual evaluation at each experimental unit (0 for no injuries, up to 100% for plant death), considering in this case, significantly visible symptoms in the plants, according to their development (VELINI et al., 1995).

Upon harvest, plant height and yield were evaluated. For height evaluation, plants were

measured, from the soil surface to the last fully expanded trifoliolate, with a wooden ruler, 10 plants evaluated per plot. For yield, the two central rows were harvested (four meters in length), the moisture was corrected to 13%.

#### Statistical analysis

Analysis of variance and F-test (P<0.05) were applied according to PIMENTEL-GOMES & GARCIA (2002). Treatment mean values were grouped by SCOTT & KNOTT'S (1974) test (P<0.05). All analyses were performed using the

Table 2 - Dates and weather conditions during herbicide applications.

	Date	Wind (km h <sup>-1</sup> )	T. (°C)	Relative humidity (%)
Exp. 1 (1st application)	Sep 13, 2018	4.1	29.1	56.1
Exp. 1 (sequential application) <sup>a</sup>	Sep 23, 2018	6.5	29.6	62.7
Exp. 2 (1st aplicação)	Sep 30, 2018	4.5	23.1	62.5
Exp. 2 (sequential application) <sup>b</sup>	Oct 14, 2018	2.8	29.2	66.3

<sup>a</sup>Performed on the same day of sowing. <sup>b</sup>Performed one day before sowing.



statistical software Sisvar 5.6 (FERREIRA, 2011). For the weed control and crop injury variables, a significant effect was verified for source experiment ( $P < 0.05$ ), then a separate analysis of each experiment was performed. For the variables height and yield of soybean, no significant effect was verified for source experiment ( $P > 0.05$ ), thus, the experiments were combined for analysis.

## RESULTS

Table 3 presents *Conyza* spp. control and soybean injury scores for experiment 1. Injury was verified for the application of glyphosate + diclosulam + saflufenacil and glyphosate + diclosulam, with percentages higher than all other treatments. Injuries were 4.3% and 3.5% for these two treatments, at 5 WAS. For the other treatments, no crop injury was observed at most 0.3%, without differences from each other even in relation to weedy or weed-free controls.

In the sowing evaluation, the treatments glyphosate + saflufenacil (92%), glufosinate + saflufenacil/imazethapyr (93%), glyphosate + diclosulam + saflufenacil (96%) provided the highest

controls of *Conyza* spp., superior to all other treatments, equal to the weed-free control with 100% control. The control evaluation performed at sowing occurred 10 days after the first application, these percentages reflected the control of the first application only. The following evaluations reflected control of the first application + sequential application of glufosinate.

At 1 WAA, 69% of control was observed for paraquat and 76% for paraquat/diuron, these two treatments remained among the worst for *Conyza* spp. control until 5 WAA evaluation, with controls of 57% and 53%, respectively. This is due to the frequency of 35% of *Conyza* spp. with indicative of resistance to paraquat, so the first application was inefficient and only the second application could not do all the control. For other treatments, from 1 to 5 WAA, a control of at least 70% was verified. Highlighting glufosinate + 2,4-D (93%), glyphosate + diclosulam + saflufenacil (96%) and glufosinate + saflufenacil/imazethapyr + 2,4-D (93%) at 5 WAA, superior to the other treatments, in the same control level observed for the weed-free control (100%).

Table 4 lists *Conyza* spp. control and soybean injury for experiment 2. As in experiment

Table 3 - *Conyza* spp. control (%) and soybean injury (\$) after herbicide application. 2018/19 season, Assis Chateaubriand (experiment 1).

	Sow	1WAA	3WAA	5WAA	2WAS	5WAS
Weedy control (without application)	0 e	0 g	0 e	0 e	0.0 a	0.0 a
gly + 2,4-D seq. glu	44 c	82 d	82 c	83 b	2.5 c	0.0 a
gly + 2,4-D + saflufenacil seq. glu	87 b	92 b	90 b	89 b	2.5 c	0.3 a
gly + saflufenacil seq. glu	91 a	93 b	91 b	89 b	0.8 a	0.0 a
glu + saflufenacil/imazethapyr seq. glu	93 a	91 b	89 b	88 b	1.8 b	0.0 a
glu + 2,4-D seq. glu	88 b	93 b	92 a	93 a	1.5 b	0.0 a
paraquat/diuron seq. glu	40 c	76 e	67 d	53 d	0.0 a	0.0 a
glu + saflufenacil/imazethapyr seq. glu	89 b	90 b	85 b	86 b	0.5 a	0.0 a
gly + glu seq. glu	84 b	87 c	80 c	80 b	0.0 a	0.0 a
gly + diclosulam seq. glu	28 d	87 c	88 b	85 b	3.3 d	3.5 b
gly + diclosulam + saflufenacil seq. glu	96 a	98 a	95 a	96 a	3.5 d	4.3 b
glu + saflufenacil/imazethapyr + 2,4-D seq. glu	89 b	95 a	94 a	93 a	1.0 a	0.0 a
paraquat seq. glu	23 d	69 f	68 d	57 c	0.0 a	0.0 a
2,4-D + saflufenacil/imazethapyr seq. glu	83 b	94 b	90 b	85 b	1.5 b	0.0 a
gly + imazethapyr/flumioxazin seq. glu	39 c	80 d	78 c	70 c	1.5 b	0.0 a
weed-free control (without application)	100 a	100 a	100 a	100 a	0.0 a	0.0 a
Mean	67.1	82.8	89.7	77.8	1.3	0.5
CV (%)	8.2	4.4	2.6	7.8	13.1	11.7
F	*	*	*	*	*	*

Sow: sowing. WAA: weeks after sequential application. WAS: weeks after sowing. gly: glyphosate. glu: glufosinate. seq.: sequential application.

1, injury symptom was registered for the application of glyphosate + diclosulam + saflufenacil (5%) and glyphosate + diclosulam (6.3%) at 5 WAS. For experiment 2, none of the treatments in the sowing evaluation were at the same level as the control of 100% weed-free control. The best percentages were observed for glyphosate + saflufenacil (84%), glufosinate + saflufenacil/imazethapyr (83%), glyphosate + diclosulam + saflufenacil (89%) and glufosinate + saflufenacil/imazethapyr + 2,4-D (84%), all of these were inferior only to the weed-free control.

As in experiment 1, also for experiment 2, the percentages in the sowing evaluation reflect the control of the first application only, with the effect of sequential application (glufosinate) observed in the following evaluations. From 1 to 5 WAA, a control of at least 77.5% was observed for the application of glyphosate + imazethapyr/flumioxazin, while for the application of glyphosate + diclosulam, 80% control. Other treatments provided excellent control ( $\geq 93\%$ ). In this area, the frequency of *Conyza* spp. with indicative of resistance to paraquat was very low (5%).

For agronomic performance, differences in height and yield were verified, with reductions in

weedy control (without application), without differences between the other treatments. Results indicated the selectivity of herbicide treatments (Table 5).

## DISCUSSION

Noteworthy is the control provided by the treatments with glufosinate. Glufosinate + 2,4-D and glufosinate + saflufenacil/imazethapyr + 2,4-D treatments are among the most effective in controlling *Conyza* spp. in both experiments. It is emphasized that glufosinate was used in the sequential application, that is, without any application of paraquat and glyphosate, but nonetheless effective in the control. Glyphosate and paraquat are a very important herbicide for weed management; however, with the increasing cases of resistant weeds, other herbicides are important when considering the management of these resistant weeds, as well as preventing the selection of new resistant biotypes.

In recent years, reports of *Conyza* spp. resistant to herbicides increased in Brazil (HEAP, 2020). *C. sumatrensis* showed multiple resistance to glyphosate and chlorimuron (SANTOS et al.,

Table 4 - *Conyza* spp. control and soybean injury after herbicide application. 2018/19 season, Palotina (experiment 2).

Treatments	-----Control (%)-----				---Crop injury (%)---	
	Sow	1WAA	3WAA	5WAA	2WAS	5WAS
weedy control (without application)	0 i	0 f	0 d	0 d	0.0 a	0.0 a
gly + 2,4-D seq. glu	47 f	85 d	91 b	93 b	0.5 b	0.8 b
gly + 2,4-D + saflufenacil seq. glu	81 c	98 a	99 a	98 a	0.8 b	1.5 b
gly + saflufenacil seq. glu	84 b	97 a	99 a	99 a	0.0 a	0.0 a
glu + saflufenacil/imazethapyr seq. glu	83 b	94 a	98 a	99 a	0.5 b	1.0 b
glu + 2,4-D seq. glu	72 d	95 a	98 a	98 a	0.5 b	0.5 b
paraquat/diuron seq. glu	60 e	94 a	98 a	95 b	0.0 a	0.0 a
glu + saflufenacil/imazethapyr seq. glu	79 c	97 a	99 a	99 a	0.5 b	0.8 b
gly + glu seq. glu	80 c	96 a	99 a	99 a	0.0 a	0.0 a
gly + diclosulam seq. glu	18 h	84 d	83 c	80 c	2.3 c	6.3 d
gly + diclosulam + saflufenacil seq. glu	89 b	97 a	99 a	99 a	2.3 c	5.0 c
glu + saflufenacil/imazethapyr + 2,4-D seq. glu	84 b	95 b	99 a	99 a	0.8 b	1.3 b
paraquat seq. glu	51 f	89 c	97 a	93 b	0.0 a	0.0 a
2,4-D + saflufenacil/imazethapyr seq. glu	79 c	95 b	97 a	98 a	0.8 b	1.5 b
gly + imazethapyr/flumioxazin seq. glu	34 g	80 e	82 c	78 c	0.5 b	1.0 b
Weed-free control (without application)	100 a	100 a	100 a	100 a	0.0 a	0.0 a
Mean	64,9	87.1	89.7	89.1	0.6	1.2
CV (%)	6,6	2.5	2.6	3.2	14.3	18.6
F	*	*	*	*	*	*

Sow: sowing. WAA: weeks after sequential application. WAS: weeks after sowing. gly: glyphosate. glu: glufosinate. seq.: sequential application.

\*Means followed by the same letter in the column do not differ from each other by SCOTT & KNOTT's (1974) test ( $P < 0.05$ ).

Table 5 - Soybean height and yield after herbicide application. 2018/19 season, Assis Chateaubriand and Palotina (means of experiments).

Treatments	Height (cm)	Yield (kg ha <sup>-1</sup> )
Weedy control (without application)	55.2 b	433 b
gly + 2,4-D seq. glu	65.4 a	2,585 a
gly + 2,4-D + saflufenacil seq. glu	67.5 a	2,488 a
gly + saflufenacil seq. glu	68.6 a	2,560 a
glu + saflufenacil/imazethapyr seq. glu	67.2 a	2,646 a
glu + 2,4-D seq. glu	67.2 a	2,651 a
paraquat/diuron seq. glu	66.2 a	2,391 a
glu + saflufenacil/imazethapyr seq. glu	65.5 a	2,593 a
gly + glu seq. glu	68.6 a	2,643 a
gly + diclosulam seq. glu	67.0 a	2,487 a
gly + diclosulam + saflufenacil seq. glu	67.0 a	2,649 a
glu + saflufenacil/imazethapyr + 2,4-D seq. glu	67.9 a	2,614 a
paraquat seq. glu	68.9 a	2,399 a
2,4-D + saflufenacil/imazethapyr seq. glu	66.2 a	2,673 a
gly + imazethapyr/flumioxazin seq. glu	67.4 a	2,328 a
weed-free control (without application)	68.3 a	2,612 a
Mean	66.5	2,422
CV (%)	5.1	11.1
F	*	*

\*Means followed by the same letter in the column do not differ from each other by SCOTT & KNOTT's (1974) test ( $P < 0.05$ ).

2014). Recent studies showed that in the western region of the state of Paraná, there are biotypes of *C. sumatrensis* with simple resistance to paraquat (ZOBIOLE et al. 2019) and multiple resistance to paraquat, glyphosate and chlorimuron (HEAP, 2020). In this way, glufosinate combined with 2,4-D and saflufenacil/imazethapyr stands out, as observed in this study.

Glufosinate (400 g a.i. ha<sup>-1</sup>) was effective in controlling glyphosate-resistant *C. bonariensis* for pre-flowering application in combination with MSMA, bromacil/diuron or metsulfuron, with scores higher than 90% at 28 DAA (MOREIRA et al., 2010). Other studies have also reported the efficacy of glufosinate in different chemical management programs in controlling *Conyza* spp. (MONTGOMERY et al., 2017; TAHMASEBI et al., 2018; ZOBIOLE et al., 2018). In addition to these results, other studies reported the efficacy of glufosinate in different management programs in controlling other weeds, for example *Amaranthus palmeri* (MANUCHEHRI et al., 2017), *Sorghum halepense* (LANDRY et al., 2016), *Digitaria sanguinalis* (AULAKH & JHALA, 2015) and *Digitaria insularis* (MELO et al., 2012; GEMELLI et al., 2013).

Another highlight is the efficacy of saflufenacil/imazethapyr in combination with glufosinate and/or 2,4-D, with final controls of at least 86% in experiment 1 and 98.5% in experiment 2. PIASECKI et al. (2017) found 96% control of *Conyza* spp. at 35 DAA for application of glyphosate (1,080 g a.e. ha<sup>-1</sup>) + chlorimuron (25 g a.i. ha<sup>-1</sup>) + 2,4-D (670 g a.e. ha<sup>-1</sup>) + saflufenacil (50 g a.e. ha<sup>-1</sup>). BYKER et al. (2013), DALAZEN et al. (2015) and CESCO et al. (2019) also observed the efficacy of glyphosate + saflufenacil in controlling *Conyza* spp. All these studies demonstrated the efficacy of saflufenacil in combination with glyphosate or glufosinate in controlling *Conyza* spp.

It is essential the adoption of different measures in the management of *Conyza* spp. in integrated weed management, herbicide rotation and combination of different sites of action for controlling herbicide-resistant weeds, and preventing the selection of resistant biotypes. On the need for rotation of herbicides with different sites of action, new transgenic traits that provide tolerance to other herbicides such as glufosinate, imidazolinones, sulfonylureas, auxin mimics, among others may be useful in the prevention and control of herbicide-

resistant weeds (GREEN, 2018; KNISS, 2018). In this context, the use of glufosinate and saflufenacil/imazethapyr was promising to control *C. sumatrensis*, resistant to paraquat, in the present study.

All treatments were selective for soybean, which showed injury in the presence of diclosulam, but this did not compromise soybean agronomic performance. In general, control levels were high for the treatments tested, except for paraquat treatments in the area with the highest frequency of *Conyza* spp. with indicative of resistant to this herbicide, and for imazethapyr/flumioxazin treatment in both areas. These results emphasized the importance of glufosinate, and showed promising results for saflufenacil/imazethapyr, for management of *Conyza* spp. with resistant to paraquat, at pre-sowing soybean.

## DECLARATION OF CONFLICT OF INTERESTS

The authors declare no conflict of interest. The founding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

## AUTHORS' CONTRIBUTIONS

The authors contributed equally to the manuscript.

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